

Anaerobic digestion foaming in Danish full-scale biogas plants: a survey on causes and solutions

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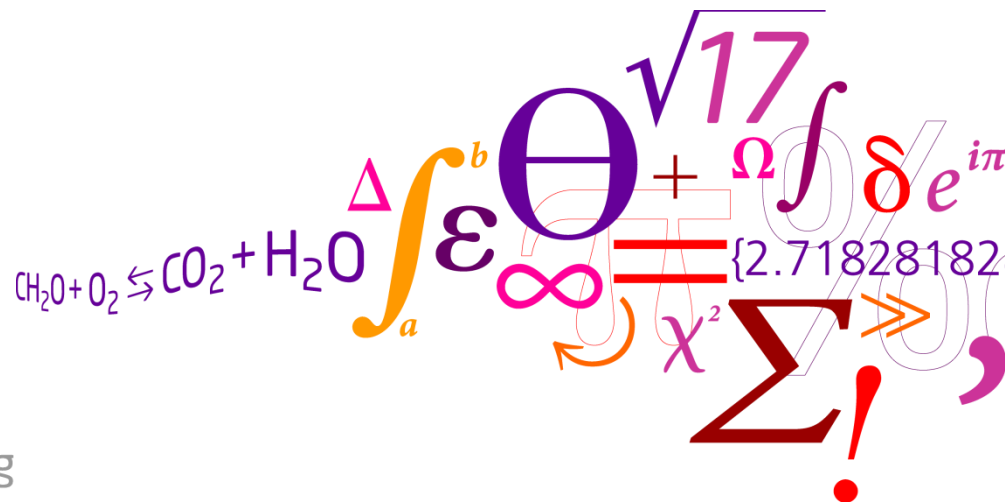
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Anaerobic digestion foaming in Danish full-scale biogas plants: a survey on causes and solutions

Kougias P.G., Boe K., O-Thong S., L.A. Kristensen and Angelidaki I.



Foam results in:

- **Operational** problems of digesters
- Creation of an **inverse solids profile** in the digesters
- Serious **economic** consequences.
- **Environmental** problems.



Parameters that can cause foam in AD:

- Surface active agents
- Organic loading
- Filamentous microorganisms
- Inadequate mixing
- Digester shape
- Temperature

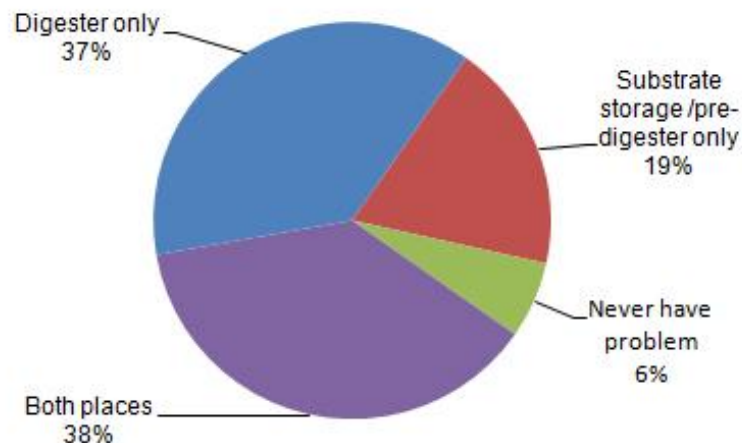


This work aims:

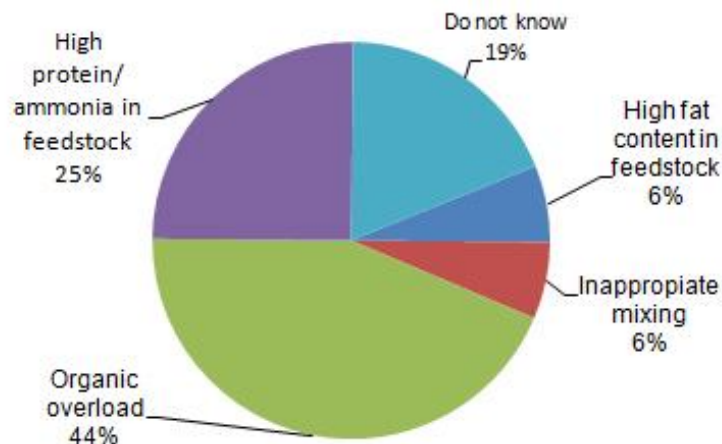
- To identify the **potential causes** of foaming in manure digesters.
- To investigate the **effect of specific compounds** commonly present in a manure digesters on liquid properties and foaming potential in manure.
- To investigate **solutions using antifoam agents.**

SURVEY (16 full-scale biogas plants in Denmark)

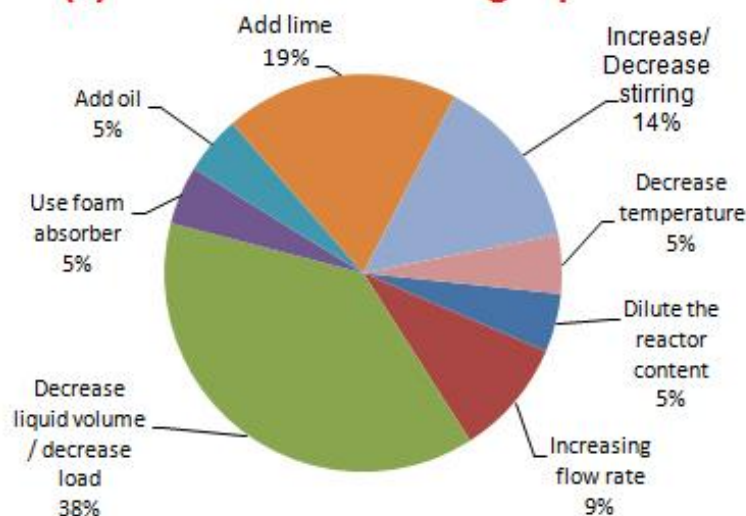
(a) Foaming problem



(b) Causes of foaming



(c) Solutions used in biogas plants



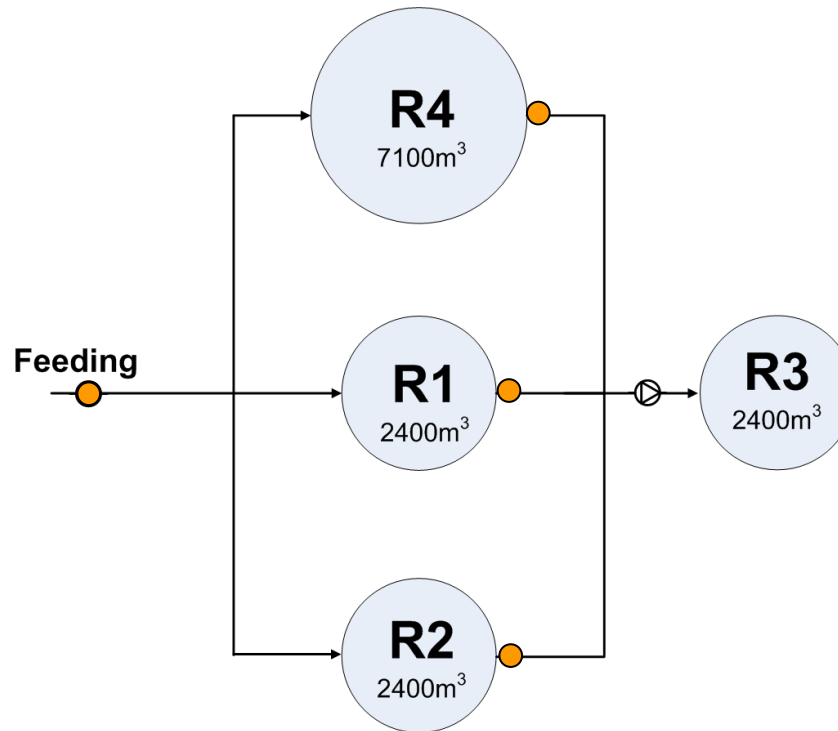
CONCLUSIONS

SURVEY

- Foaming has been recorded in the majority of the full-scale biogas plants in Denmark (**20-50% biogas production loss**)
- **Organic overload** and **the high protein and ammonia concentration** in the feedstock as the most dominant factors for foaming.
- Most common antifoam solution: **Decrease of the organic load or the liquid volume.**



CASE STUDY (Lemvig biogas plant)



- R1, R2, R4 are primary reactors fed with the same substrate.
- R3 is a second stage reactor.
- **Only R4 faced excessive foaming problems (max. 1065 tons foam/day).**

CASE STUDY (Lemvig biogas plant)

Characteristics of feedstock and reactors

Parameters	R1	R2	R3	R4	Manure	Industrial waste
pH	8.13	8.11	8.15	8.21	6.5	4.3
Alkalinity	5.2	4.5	7.5	8.1	6.2	0
Total VFA (g/L)	0.02	0.02	0.09	0.14	8.9	24.6
Biosurfactant activity (mm ²)	5	8.2	7.3	9.1	12.5	3.1
Foaming tendency (ml foam/ml-air.min)	25-50	10-90	100-150	100-200	50-100	20
Foam stability (ml)	0	0	30	30	0	0
Mixing speed (rpm)	200	200	200	16	-	-
Reactor size (m ³)	2400	2400	2400	7100	-	-

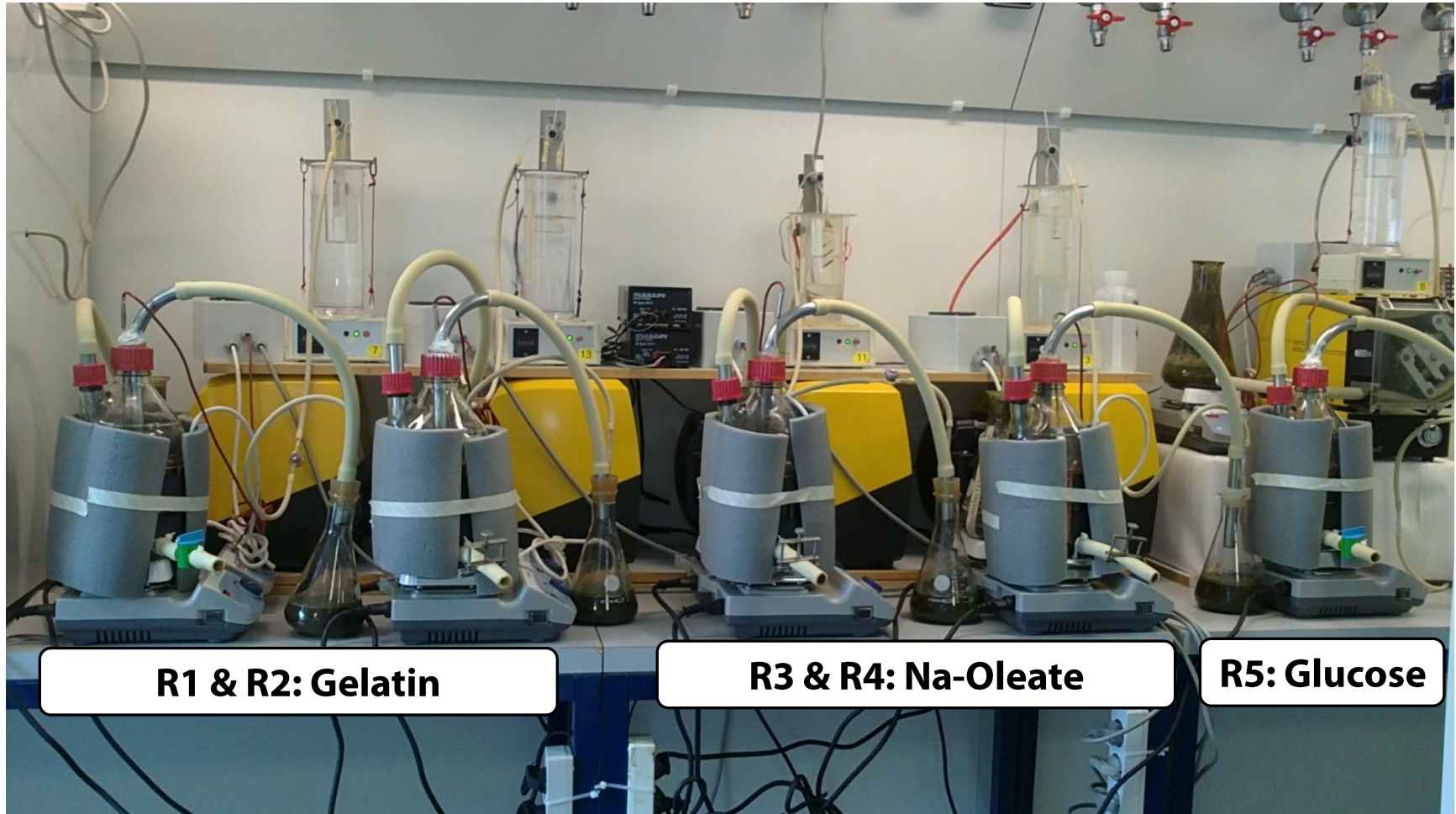
CONCLUSIONS

CASE STUDY

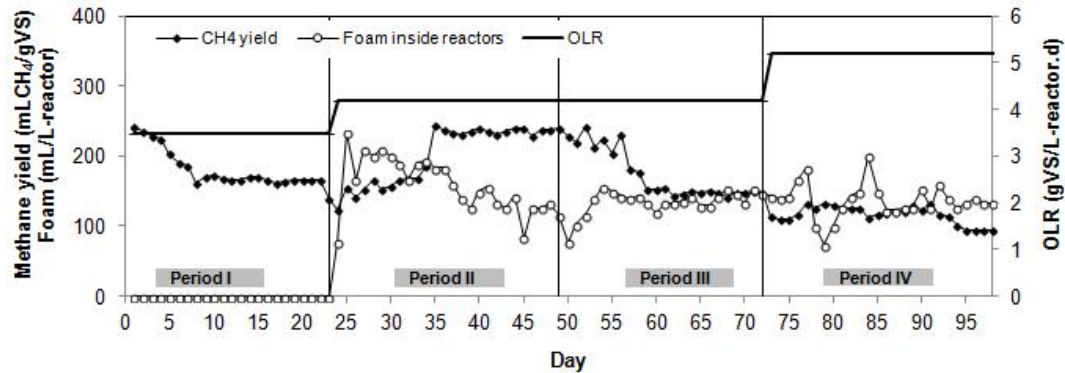
- **Feedstock composition** and the **mixing speed** of the reactor has to be taken into serious consideration in order to avoid foaming incidents.
- Foaming incidents were **not related to** the presence of specific **microorganisms**.



Effect of OLR and feedstock composition

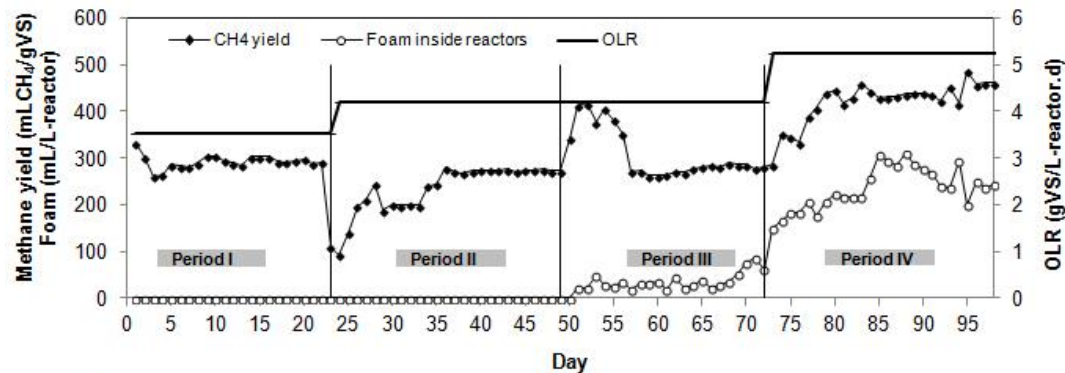


Effect of OLR and feedstock composition



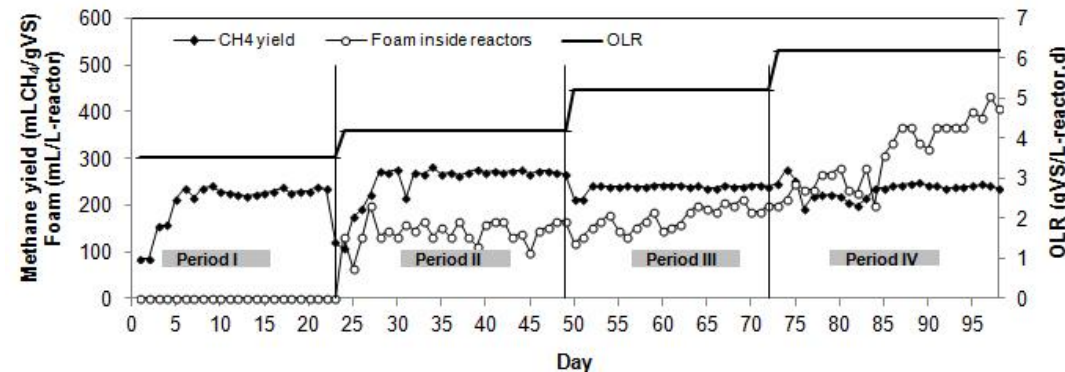
GELATIN

Foam initiation at OLR of 4.2 gVS/L-reactor·d



Na-OLEATE

At OLR 4.2 gVS/(L-reactor·day), low concentration of Na-Oleate (Period II) showed antifoaming effect.



GLUCOSE

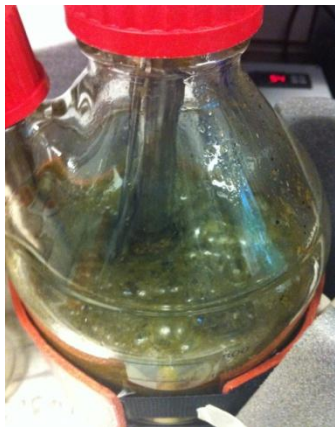
Foam initiation at OLR of 4.2 gVS/L-reactor·d

Decrease in methane yield

CONCLUSIONS

CONTINUOUS MODE EXPERIMENT:

- **Organic load** was the main factor affecting foaming.
- Protein initiated foaming at **lower OLR** than lipids.
- Foaming from proteins had **more stable volume** compared to lipids.
- **OLR of 3.5 gVS/(L-reactor·day)** was the critical threshold for foaming.
- **Foaming is rather related to increase of biogas production** and not inhibition.



Thank you!

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